it is continuous or consists of bright lines. On account of the low magnifying-power of the instrument, the red prominence would appear sufficiently small to permit of bright lines being distinguished on its spectrum, if such should exist.

The instrument should be previously focused by the observer on the moon, or some distant object.

Should a portion of the sun's limb be visible, the instrument must be rotated until the spectrum of the little projecting prominence appears in a direction parallel to that of the spectrum of the sun's limb, and is not overlapped by it. Perhaps a diaphragm across the field of view and cutting off about one-third of it would be an advantage, as the spectrum of the sun's limb might be concealed behind it. The eye, relieved in this way from the bright solar spectrum, would be in a more favourable state to examine the fainter spectrum of the red prominence.

Four of these instruments, made by Mr. Browning, have been sent out by the Royal Society to India, to be placed in the hands of observers stationed at different places along the central line of the eclipse. This instrument would be specially suitable for use at sea.

Postscript.—Mr. Browning has recently suggested a method of diminishing the apparent velocity of meteors by the use of a concave cylindrical lens placed with its axis perpendicular to the direction of their motion. This mode of observing may be applied to the spectrum-telescope by substituting, when required, a plano-convex cylindrical lens for the eye-lens of the eyepiece. If this lens be placed with its axis parallel to the height of the compound prism before the object-glass, and if the telescope be held in a position such that the direction in which the light of the meteor is dispersed is perpendicular to that of its motion, the spectrum of the meteor will be magnified, as when the ordinary eye-lens is employed, but the apparent velocity of the meteor will be less by an amount equal to the magnifying-power of the eye-lens.

January 30, 1868.

Lieut.-General SABINE, President, in the Chair.

The following communications were read:—

I. "Remarks upon *Archæopteryx lithographica*." By Prof. T. H. Huxley, LL.D., F.R.S. Received January 1, 1868.

The unique specimen of *Archæopteryx lithographica* (von Meyer) which at present adorns the collection of fossils in the British Museum, is undoubtedly one of the most interesting relics of the extinct fauna of long-past ages; and the correct interpretation of the fossil is of proportional importance. Hence I do not hesitate to trouble the Royal Society with

the following remarks, which are, in part, intended to rectify certain errors which appear to me to be contained in the description of the fossil in the Philosophical Transactions for 1863*.

It is obviously impossible to compare the bones of one animal satisfactorily with those of another, unless it is clearly settled that such is the dorsal and such the ventral aspect of a vertebra, and that such a bone of the limb-arches, or limbs, belongs to the left, and such another to the right side.

Identical animals may seem to be quite different, if the bones of the same limbs are compared under the impression that they belong to opposite sides; and very different bones may appear to be similar, if those of opposite sides are placed in juxtaposition.

The following citations, and the remarks with which I accompany them, however, will show that these indispensable conditions of comparison have not been complied with in the memoir to which I refer.

1. "The moiety (Plate I.) containing the greater number of the petrified bones exhibits such proportion of the skeleton from the inferior or ventral aspect" (*l. c.* p. 34).

I propose to show, on the contrary, that the fossilized animal presents, in general, its dorsal aspect to the eye, though one of the most conspicuous bones may have been so twisted round as to exhibit its ventral face.

2. The demonstration that the bones of the *Archæopteryx* are thus wrongly interpreted, may be best commenced by showing that what is called "right femur (65), tibia (66), and bones of the foot (68, *i, ii, iii, iv*)," *l. c.* p. 35, are respectively the left femur, left tibia, and bones of the left foot.

That such is the case is very easily proved by the circumstance that (as is very properly pointed out in the memoir) the second toe of the foot in question is that which lies uppermost, while the plantar surface of the foot is turned outwards, and its dorsal aspect towards the vertebral column.

If the limb in question were, as the describer of the fossil supposes, the right leg, it would obviously be impossible to place the foot in its present position, unless the numbers of the phalanges in its toes were the reverse of what is observed in Birds; that is to say, the uppermost toe, that which has three phalanges, must also be the outermost. Nevertheless the describer of the fossil justly lays great stress upon the fact that the toes have the same number of phalanges as in birds. As a matter of fact, this is quite true; but it would not be true if we were to assume with him that the limb in question is the right leg.

3. Certain parts of the fossil which lie upon the opposite side of the spine to the so-called "right leg" are named, at p. 34 of the memoir cited, "Portion of the left os innominatum, showing part of the ilium (62) and ischium (63), with the acetabulum (*a*)."

* "On the *Archæopteryx* of Von Meyer, with a description of the Fossil Remains of a Long-tailed Species, from the lithographic stone of Solenhofen." By Professor Owen, F.R.S. &c.

A full description of this mass of bone as "the left os innominatum, including the anterior two-thirds of the ilium, and the anterior half, or more, of the coalesced ischium," is given at p. 39; and at p. 40 I find, "The inferior or central * face [of the sacrum], *as in the case of the slightly dislocated left innominatum,* is towards the observer."

There is no doubt on any side, that the end of the bone in question which at present is directed forwards is its true anterior end, and that the edge which is turned towards the spinal column is the true dorsal edge. The question is, whether the face of the bone which is exposed is its outer (or dorsal) or its inner (or ventral) face. In the former case it must needs be a right ilium, in the latter a left ilium.

That it is the outer face of the bone which lies uppermost appears to me to be demonstrated—

(*a*) By the fact that the iliac margin of the acetabulum is prominent, and that the adjacent surface of this ilium rises to this margin. I am not aware that any vertebrate animal exists in which the acetabulum lies at the bottom of a funnel-shaped depression, such as would be the case in *Archæopteryx* if the bone in dispute were the left os innominatum seen from the inner side.

(*b*) By the fact that a small portion of what appears to be an innominate bone can be descried in close relation with the proximal end of what has just been shown to be the left femur; while the right femur (called left in the memoir), though dislocated, is not very far from the bone under discussion.

(*c*) By the further consideration, that if this were not the right os innominatum, it would be as curiously unlike the corresponding bone of a bird in the form of its surface as it resembles it in all other respects.

4. The bone marked 51′ is named "left scapula" (*l. c.* p. 34), and that marked 51 "right scapula" (*l. c.* p. 35); and a full description of these bones, as such, is given at pp. 36 and 37 of the memoir cited.

Nevertheless I venture to affirm that 51′ is the right scapula and not the left; for it will not be denied that the anterior or glenoidal end of the bone, as it now lies, is directed forwards, its posterior or vertebral end backwards, and its glenoidal articular surface outwards and forwards: it would be quite impossible to put a left scapula of similar construction into this position.

Further, the glenoidal end of this scapula remains in connexion with what is obviously the glenoidal (or humeral) end of the right coracoid (marked *c* in Plate I.). The author of the memoir, indeed, gives a different interpretation of the osseous projection thus marked (*l. c.* p. 37):—

"The prominence beyond the left scapula (Plate I. 51′) suggested at first view the humeral end of the coracoid, but I believe it to be part of the humerus corresponding with the tuberosity on the ulnar side of the sessile semioval head, overarching the pneumatic foramen in the bird."

* "Central" in the original. The word appears to have been substituted by an error of the press for "ventral."

And this view is pictorially embodied in the restoration of the humerus of *Archæopteryx* given in Plate II. fig. 1.

But a most distinct line of matrix separates the humerus from the prominence in question, in which may be seen, with great clearness, the glenoidal facet of the coracoid, as well as the excavation of the exterior surface of the bone which is characteristic of the glenoidal, or humeral, end of the coracoid in birds and pterodactyles.

I think, then, there can be no question that the parts marked 51′ and *c* in Plate I. of the memoir cited are the right scapula and the glenoidal end of the right coracoid, and not, as the author affirms, the left scapula and a tuberosity of the humerus.

5. Even apart from the fact that the humerus marked 53′ lies in almost undisturbed relation with the right pectoral arch, it is obviously a right humerus. On no other supposition can the relative position of the deltoid ridge and of the various contours of the bone be accounted for. Nevertheless this is called "proximal half of left humerus (53′), entire, and part of the distal half" at p. 34 of the memoir cited.

It is probably needless to pursue this part of the inquiry any further. As the so-called right leg turns out to be the left, the so-called left os innominatum the right, and the so-called left scapula and wing-bones to be those of the opposite side of the body, the necessity of a corresponding rectification for the other limb-bones needs no evidence.

6. As both the hind limbs and one-half of the pelvis have just such positions as they would readily assume if the hinder part of the animal's body lay upon its ventral face, it is highly improbable (to say the least) that the caudal and posterior trunk-vertebræ should have turned round so as to present their ventral aspect to the eye, as they do according to the memoir (*l. c.* p. 44).

But I apprehend that evidence can be found in the vertebræ themselves sufficient to prove that their dorsal and not their ventral faces are turned towards the eye. In several of the best-preserved of these vertebræ, in fact, (and Plate I. imperfectly shows this,) the remains of two small articular poocesses are distinctly visible at each end of the vertebra. The superior surface of each articular process is raised into a low longitudinal ridge; and the posterior pair of processes lie at the sides of a narrow, parallel-sided plate of bone, which projects beyond the posterior edge of the vertebra, and is received between the anterior articular processes of the vertebra which succeeds it. A low linear longitudinal elevation occupies the place of spinous process.

If my interpretation of these appearances is correct, it is clear that the caudal vertebræ (as was to be expected) turn their dorsal faces to the eye.

7. One important and extremely conspicuous bone, the furculum (if it be such), undoubtedly turns its ventral surface to the eye; and I cannot but suspect that it is the *bouleversement* of this bone which has led to that reversal of the proper nomenclature of the other bones which, could it be

sustained, would leave *Archæopteryx* without a parallel in the vertebrate subkingdom.

When the specimen of *Archæopteryx* is once put into its right position, many points of its structure acquire an intelligibility which they lose to those who accept the interpretations given in the memoir. The so-called right foot, for example, which, as a right foot, is like nothing in nature, becomes strikingly ornithic as a left foot, from the backward direction of the hallux and the apparent anchylosis of the metatarsal bones. The distal ends of the second and third metatarsals appear to me, however, to be separated for a much greater distance, proportionately to the length of the metatarsus, than in any existing birds, except the Penguins.

The femur is more slender and more curved in proportion to its length than in any recent bird with which I am acquainted. The representation of the bone in fig. 1 of Plate III. is inaccurate, as may be seen by comparing it with that given in Plate I.

The small size of the cnemial crest of the tibia is also very remarkable.

The right innominate bone is imperfectly represented in Plate I. of the memoir cited. Its anterior end is not, as it there appears to be, abruptly truncated: there is an elevation in the region which would be occupied by the prominence against which the base of the great trochanter works, and which is so characteristic of birds. The greater part of the ischium is not represented; and the sacrosciatic space certainly has not the form which it is represented to have. The references *o* to the "obturator foramen," and 63, to the "ischium" (*l. c.* p. 40), are unintelligible to me.

The ischium can be traced back for $\frac{3}{4}$ of an inch from the acetabulum; and so much of it as is preserved remains narrow throughout this extent, and is convex upwards, but concave downwards or towards the matrix.

The ventral edge of the ischium appears to be entire throughout this extent; but the posterior moiety of its dorsal edge is somewhat rough and angular. It is therefore very probable that the ischium expanded behind the sacrosciatic notch and united with the ilium, as it very generally does in carinate birds. It is very desirable that this part of the skeleton of *Archæopteryx* should be figured again.

The scapula has a distinct clavicular process, as in carinate birds; and it seems to be pretty clear that the scapula had that twofold angulation upon the coracoid which is characteristic of the *Carinatæ*.

The glenoidal end of the coracoid is unlike the corresponding part of that bone in any of the *Ratitæ*; but it is more like that of a Pterodactyle than that of any carinate bird which I have met with. It is less prominent (and the counterpart shows that this shortness is not the result of fracture) than in any recent bird, provided with a strong furculum, with which I am acquainted. In fact, in its form, and strength relatively to the shoulder-girdle, the so-called "furculum" appears to me to be the greatest osteological difficulty presented by *Archæopteryx*. I prefer waiting for the

light which will be afforded by another specimen to the indulgence of any speculation regarding this bone; in the meanwhile, I by no means wish to deny that appearances are strongly in favour of the interpretation which has been put upon it.

In conclusion, I may remark that I am unaware of the existence of any "law of correlation" which will enable us to infer that the mouth of this animal was devoid of lips, and was a toothless beak. The soft tortoises (*Trionyx*) have fleshy lips as well as horny beaks; the *Chelonia* in general have horny beaks, though they possess no feathers to preen; and *Rhamphorhynchus* combined both beak and teeth, though it was equally devoid of feathers. If, when the head of *Archæopteryx* is discovered, its jaws contain teeth, it will not the more, to my mind, cease to be a bird, than turtles cease to be reptiles because they have beaks.

All birds have a tarso-metatarsus, a pelvis, and feathers, such, in principle, as those possessed by *Archæopteryx*. No known reptile, recent or fossil, combines these three characters, or presents feathers, or possesses a completely ornithic tarsometatarsus, or pelvis. *Compsognathus* comes nearest in the tarsal region, *Megalosaurus* and *Iguanodon* in the pelvis. But, so far as the specimen enables me to judge, I am disposed to think that, in many respects, *Archæopteryx* is more remote from the boundary-line between birds and reptiles than some living *Ratitæ* are.

II. "Account of Experiments on Torsion and Flexure for the Determination of Rigidities." By Joseph D. Everett, D.C.L., Professor of Natural Philosophy in Queen's College, Belfast. Communicated by Sir William Thomson. Received January 13, 1868.

(Abstract.)

This paper describes a continuation of experiments related in two former papers, read February 22, 1866, and February 7, 1867,—the substances operated on in the new series being wrought iron, cast iron, and copper, and the mode of procedure being the same as in the latter of the two preceding series. The results obtained, along with those published in the former papers, are given below, the figures I., II., III. indicating the paper in which the results are deduced. The values of M, n, and k are in millions of grammes weight per square centimetre.

	M, Young's modulus.	n, Rigidity.	k, Resistance to compression.	σ, Poisson's ratio.	Specific gravity.
Glass, flint, I.	614·3	244·2	423·0	·258	2·942
Do. II. ...	585·1	239·0	353·3	·229	2·935
Brass, drawn, II....	1094·8	372·9	5701 (?)	·469	8·471
Steel, cast, II.....	2179·3	834·1	1875·6	·310	7·849
Iron, wrought, III.	1999·4	783·8	1484·1	·275	7·677
Iron, cast, III.....	1374·1	542·3	982·2	·267	7·235
Copper, drawn, III.	1255·8	455·6	1716·4	·378	8·843